9-1978

Energy in Agriculture: Energy for Swine Facilities Part I: Energy Conservation

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ENERGY IN AGRICULTURE

ENERGY FOR SWINE FACILITIES PART I: ENERGY CONSERVATION

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INTRODUCTION

Recently, there has been some concern about energy utilization in agricultural production. Shortages of natural and LP gas have affected many livestock producers, especially swine producers utilizing LP gas as a supplemental heat source in farrowing facilities. These shortages, coupled with an ever-increasing price for fuel and electricity, have encouraged many producers to begin looking for ways to reduce energy consumption.

Fan energy and heat added to maintain the temperature in farrowing houses and nurseries, called "supplemental heat," are the two major energy costs in confinement swine facilities, excluding feed energy. Supplemental heat may take several forms, some of which may not be recognized as supplemental heat sources. One source is the creep heat used for small pigs. In a well-insulated building creep heat can provide a large amount of the heat required to maintain the temperature in a building. However, the creep heat added in the summer time requires higher ventilation rates to control temperatures, thereby increasing fan energy costs. Other uses of energy in swine housing include the lighting and feed handling.

When considering energy conservation one must understand that present systems now utilize large amounts of energy because by utilizing more energy it is possible to eliminate or reduce the management input into the system. As shown in Figure 1, high energy/low management systems can be replaced with a low energy system, but, in

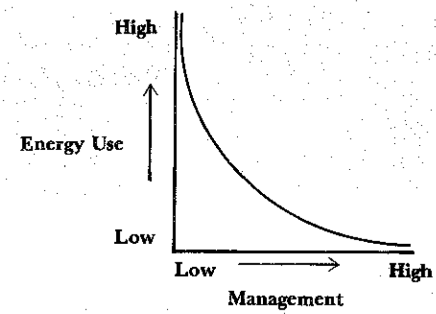
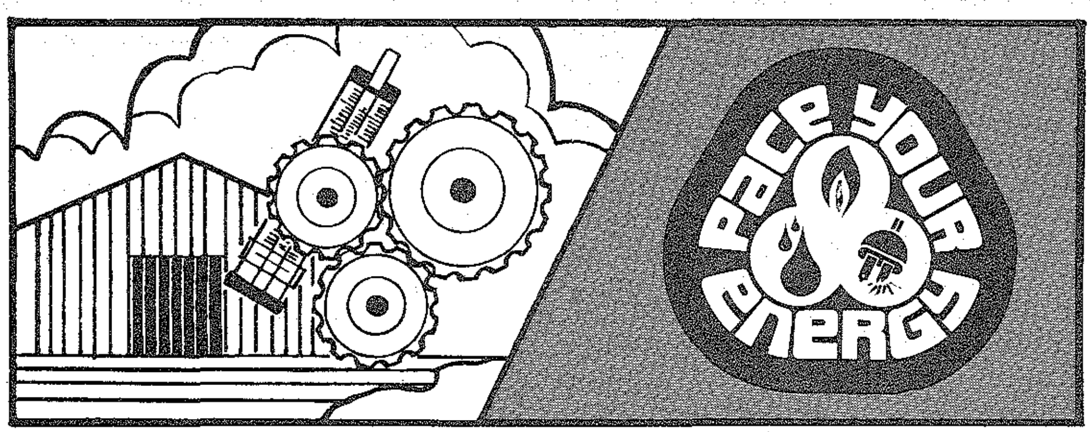


Figure 1.—The relationship between the level of energy use and management of swine facilities.



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general, this will increase the level of management required by the individual producer. Therefore, in reviewing different methods to reduce energy consumption, remember that they may increase the level of management required for the system.

ENERGY REDUCTION METHODS

Insulation

One of the most common ways of saving energy is adding insulation. Because farrowing houses and nurseries are held at high temperatures, 70°F and above, proper insulation is required for these structures, especially if these facilities are used the year around (Table 1).

Table 1.–The Effect of Insulation Level on the Supplemental Heat Cost in a Farrowing Facility.

Assumptions:	18-Stall Farrowing Facility 30 cfm/stall 80°F Inside LPG 50¢/gal	 30°F Outside
		Heat Cost for January
Uninsulated (R=2)		$515.00
Some Insulation (R=8)		$150.00
High Insulation (R=18)		$100.00

In general, the insulation requirements for swine housing are less than those for a residence because swine housing has a good heat source within it–the animals themselves. This is especially true in a nursery or grower facility where there is a high density of animals. Because the animals provide some heat the supplemental heat requirements are lowered, reducing the savings received by adding insulation. It is advisable under winter conditions to always keep a facility as full as possible because the animals are providing a heat source.

Improper use of insulation in swine facilities may create problems. There have been instances where insulation in livestock buildings has become wet, reducing its effectiveness. In most of these cases the problem has occurred because water vapor in the air inside the building has gotten into the insulation and condensed. Typically, in a residence in the winter, relative humidity levels are 30-40% or less; however, in some livestock facilities relative humidity levels are 70-80% or higher. This causes moisture problems to be more prevalent in livestock facilities than in residences. To prevent these problems a high-quality vapor barrier must be used. It should be installed as close to the warm side of the wall as possible.

Vapor barriers include aluminum foil, plastic, and some insulation boards. However, it should be noted there is a distinction between the two types of "styrofoam" board, the solid board and bead board: bead board is not a vapor barrier. Some problems have occurred in livestock facilities where bead board was used as insulation material and left uncovered with no vapor barrier provided. The water vapor in the building condensed in the bead board and saturated it, and the added water weight caused it to fall from the ceiling.

It is possible to assess the savings that can occur from adding insulation. For example, an uninsulated 18-stall farrowing building operating at 80°F with a ventilation rate of 30 cfm (cubic feet per minute) per sow will have a supplemental heat cost of $515 (Table 1). This is for the month of January, with an average outside temperature of 30°F. Table 1 also shows that the savings for using some insulation at levels similar to those given in Table 2, in the same facility, can save $365 in supplemental heat cost. However, if the level of insulation is increased to what might be considered a high insulation level, the additional saving in supplemental heat cost is only $50 more than the moderate insulation level. Remember, these savings are for an average January and would be greater if the entire winter were evaluated. For many buildings the January supplemental heat cost is about one-half of the total yearly heat cost.

Table 2.–Currently Recommended Insulation Levels for Swine Facilities.

R value of the Walls	= 9
R value of the Ceiling	= 12

Table 1 also shows the concept of marginal returns with the addition of insulation to both livestock housing and to the home in general. As the total amount of insulation increases, the savings from the last layer of added insulation rapidly decrease. Therefore, in an uninsulated building relatively large energy savings would be realized by installing some insulation. In a building which is already insulated to some degree, increasing the insulation level should be evaluated more closely.

Fan Maintenance, Selection

Fan maintenance and selection is another way to reduce the energy requirements of swine facilities. Fan maintenance is a problem in swine facilities because of the dust which accumulates, coating the fan blades and shutters. Research has never established figures that show any savings from cleaning fan blades themselves, although if the conditions are severe a problem with the motor could develop. However, if the shutters are not clean and cannot operate freely they can reduce fan performance by 20% (4). That is, during a year there will be a 20% increase in operating costs for a fan if its shutters are dirty and cannot open completely. When shutters are installed on a fan they decrease efficiency somewhat. Some research indicates that if a fan operates continuously year-round, no shutter should be used. In a facility like a farrowing house, which has a fan that runs continuously when there are animals in the building, some type of shutter or door will be needed to close the facility when no livestock are present. However, when the fan is operating the shutter or door should be held in an open position.

In past years, fan selection did not receive careful attention. Studies have shown that there are large differences in fan efficiencies (1), but the relatively inexpensive cost of fan operation also kept interest low. However, now with electrical costs increasing, producers are becoming more concerned about the efficiencies of fans. This has resulted in a proposed new rating system for fans, which would rate fans for the cfm (cubic feet per minute) of air moved per watt of power used. In this system a fan having a high cfm/watt rating would move more air at a lower electrical cost than a fan having a low cfm/watt rating. Typically, these numbers range anywhere from 10 to 20, which indicates that some fans are twice as efficient as others. The importance of these ratings can be seen by looking at the savings for a 2,000 cfm fan that runs continuously year-round, using electricity costing 3¢/kwh. As shown in Table 3, the low-quality fan, with a 12-cfm/watt rating, cost about $45 a year while a high-quality fan with a 19-cfm/watt rating cost only $20 a year to operate. Therefore, proper fan selection represents a simple way to save $25 a year. It also demonstrates that a higher priced fan with a good performance characteristic in terms of cfm/watt may be a wise investment.

Table 3.—Savings which can Result from Proper Fan Selection.

Assumption: 2,000 cfm Fan, operating continuously

	Cost of Operation
Low-Quality Fan—12-cfm/watt	$45.00/year
High-Quality Fan—19-cfm/watt	20.00/year
Savings =	$25.00/year

Ventilation Rate

Given the large portion of energy use in swine facilities resulting from the ventilation of the building, it is important to consider the effects of ventilation rate on energy consumption within a facility. Ventilation is required for four major reasons: to maintain temperature, control moisture, control odors and provide oxygen. While providing oxygen is the primary reason for ventilation, most ventilation systems are operated to maintain the air temperature in a facility. A minimum amount of ventilation must be provided to control moisture in livestock facilities. This method provides sufficient oxygen and will also control odors.

When the ventilation control system is operated only to maintain the temperature in the facility, the humidity level can become high in the winter time. This requires that a minimum ventilation rate be used to control the humidity within the building. At these minimum rates a certain amount of supplemental heat is required to maintain the temperature within the facility when outside air temperatures are low.

Table 4 shows the effects of ventilation rate on the total cost of operating an 18-stall farrowing house, during average January conditions. Beginning with a ventilation rate of 50-cfm/stall for the building, the total cost of operation is over $300. By reducing the ventilation rate to 30-cfm/stall the total cost is reduced to $200. If the ventilation rate is reduced to the minimum, which would be acceptable for moisture control, the total cost would be about $100. Clearly, substantial savings will result from reducing the ventilation rate.

Table 4.—The Effect of Ventilation Rate on the Total Energy Cost, Excluding Feed, of a Farrowing Facility.

Assumptions: 18 Stalls, 80°F Inside, LPG 50¢/gal; Some Insulation, 30°F Outside, Electricity 3¢/kwh

	Total Cost for January
900 cfm (50-cfm/stall)	$335.00
540 cfm (30-cfm/stall)	200.00
275 cfm (moisture control)	95.00

Why are recommended rates so high? As the ventilation rate is reduced an increased level of management is required. Relatively high ventilation rates are recommended because they will provide a proper environment with little management. They allow for some error in fan ratings, and require a low level of management. Also, small fans can be difficult to obtain. However, it is completely acceptable to reduce high ventilation rates as long as the humidity level and odors are maintained at acceptable levels. But, if lower ventilation rates are used, the manager must continually observe the conditions in the facility and be able to adjust the ventilation rate if problems occur.

Thermostat Setting

The thermostat setting in a facility also greatly affects energy use. The general guideline for buildings is that the lower the temperature within the building that can be tolerated, the lower the fuel cost will be. However, there are hidden costs here, because when the temperature within a facility is reduced, additional energy in the form of feed will be required. This is especially true with nursery animals.

The effect of the temperature setting can be shown with the farrowing house example. Two different management strategies are considered—one, using normal farrowing facility operating procedure of not adjusting ventilation rates, and another that reduces the ventilation rate to control moisture. Table 5 shows the effect of thermostat setting for both management strategies for an average January. An increase in the total operating cost, especially in an uninsulated facility, can be seen for all three levels of insulation by raising the thermostat from 70°F to 80°F. However, in a well-insulated facility with the ventilation rate adjusted to provide moisture control, the effect on the total energy use of increasing the thermostat setting depends on the level of insulation. In the facility with no insulation the cost rises from $340 to $390, a $50 increase, but in facilities with some insulation almost no change occurs in operating cost. In a highly-insulated facility there is some reduction in operating cost by increasing the thermostat setting.

The reason the total operating cost for a well-insulated facility decreases as the thermostat setting increases is not obvious. The ability of the air to hold moisture at various conditions is shown in Table 6. It can be seen that when outside air at 30°F and 50% relative humidity enters a facility and is warmed to 80°F, the humidity drops to 10%. This warmed outside air has a large moisture-holding capability. When the relative humidity in the inside air is increased to 70%, there is a large difference in the moisture between 80°F air and 70°F air. Table 6 shows that air at 80°F and 70% relative humidity has equivalent moisture to air at 70°F and 100% relative humidity. So, for a building at 80°F the relative humidity would be acceptable, although slightly high, but if it was 70°F there would be a moisture problem within the facility, and the minimum ventilation rate would need to be increased to maintain acceptable conditions. Thus, in a well-insulated building, the increase in heat loss caused by increasing the thermostat setting is less than the reduction in heat loss through the ventilation system if the ventilation rate is reduced to the minimum required to control moisture for that temperature. Therefore, a small net energy savings is realized.

Table 5.—The Effect of Temperature Setting on the Total Energy Saving, Excluding Feed Energy, of a Farrowing Facility.

Assumptions: 18 stalls
LPG 50¢/gal Electricity 3¢/kwh
30°F Outside
Ventilation Rate = 30 cfm/stall

Temperature Setting =	Total Cost for January 70°F	80°F
Uninsulated (R=2)	$380	$560
Some Insulation (R=8)	150	200
High Insulation (R=18)	110	150
Ventilate for Moisture Control		
Uninsulated	340	390
Some Insulation	100	95
High Insulation	60	45

Ventilation Rate for moisture control
70°F - 400 cfm
80°F - 275 cfm

Table 6.—The Air's Moisture Holding Ability at Different Temperatures.

30°F 50%RH = 80°F 10% RH
70°F 70%RH = 80°F 50% RH
80°F 70%RH = 70°F 100% RH

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Charles E. Barnhart, Director of Cooperative Extension Service, University of Kentucky College of Agriculture, Lexington, and Kentucky State University, Frankfort.

Issued 9-78, 3M; 1.5M—11-81